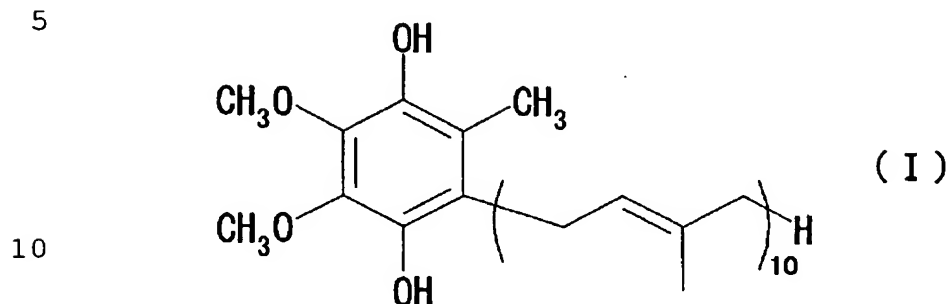


CLAIMS

1. A process for producing the reduced coenzyme Q₁₀ represented by the following formula (I):



which comprises culturing reduced coenzyme Q₁₀-producing microorganisms in a culture medium containing a carbon source, a nitrogen source, a phosphorus source and a micronutrient to obtain microbial cells containing reduced coenzyme Q₁₀ at a ratio of not less than 70 mole % among the entire coenzymes Q₁₀, optionally disrupting the microbial cells and extracting thus-produced reduced coenzyme Q₁₀ by an organic solvent.

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2. The process according to Claim 1, wherein the reduced coenzyme Q₁₀ is contained at a ratio of not less than 70 mole % among the entire coenzymes Q₁₀.

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3. The process according to Claim 1 or 2, wherein the production amount of reduced coenzyme Q₁₀ on completion of the culture is not less than 1 µg/mL.

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4. The process according to any one of Claims 1 to 3, wherein the culture is carried out at 15 to 45°C and at a pH of 4 to 9.

5. The process according to any one of Claims 1 to 4,

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wherein the concentration of the carbon source in the culture is controlled to a concentration that no adverse effects are substantially caused on the productivity of reduced coenzyme Q₁₀.

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6. The process according to Claim 5,
wherein the culture is carried out by a fed batch culture method.

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7. The process according to Claim 6,
wherein the carbon source is supplied to the culture medium separately from other components.

15

8. The process according to any one of Claims 1 to 7,
wherein the culture is carried out aerobically.

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9. The process according to any one of Claims 1 to 8,
wherein the microbial cells are disrupted in the extraction.

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10. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment, a chemical treatment, an enzymic treatment, a heating treatment, an autolysis, an osmolysis or a plasmoptysis.

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11. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment, an acid treatment with a strong acid or a heating treatment.

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12. The process according to Claim 9,
wherein the cell disruption is carried out by a physical treatment.

13. The process according to Claim 12,
wherein the physical treatment is carried out by a
high pressure homogenizer, an ultrasonic homogenizer, a
French press or a ball mill.

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14. The process according to any one of Claims 9 to
13,

wherein the cell disruption is carried out under an
acidic to a weakly basic condition.

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15. The process according to any one of Claims 1 to
14,

wherein, as the organic solvent to be used for
extraction of reduced coenzyme Q₁₀, at least one species of
hydrocarbons, fatty acid esters, ethers and nitriles is
used.

15

16. The process according to any one of Claims 1 to
14,

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wherein the extraction of reduced coenzymes Q₁₀ is
carried out from wet cells or dry cells of the microbial
cells or disrupted product thereof by using a hydrophilic
organic solvent.

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17. The process according to Claim 16,
wherein the hydrophilic organic solvent is acetone,
acetonitrile, methanol, ethanol, 1-propanol or 2-propanol.

18. The process according to any one of Claims 1 to
15,

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wherein the extraction of the reduced coenzymes Q₁₀
is carried out from an aqueous suspension of the microbial
cells or disrupted product thereof by using a hydrophobic
organic solvent.

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19. The process according to Claim 18,
wherein the hydrophobic organic solvent is a
hydrocarbon, a fatty acid ester or an ether.

5 20. The process according to Claim 18 or 19,
wherein the hydrophilic organic solvent is used as an
auxiliary solvent in combination with the hydrophobic
organic solvent.

10 21. The process according to Claim 20,
wherein the hydrophobic organic solvent is a
hydrocarbon, and the hydrophilic organic solvent is an
alcohol.

15 22. The process according to Claim 20,
wherein the hydrophobic organic solvent is an
aliphatic hydrocarbon, and the hydrophilic organic solvent
is a monohydric alcohol containing 1 to 5 carbon atoms.

20 23. The process according to Claim 20,
wherein the hydrophobic organic solvent is at least
one species of hexane and heptane, and the hydrophilic
organic solvent is at least one species of methanol,
ethanol, 1-propanol and 2-propanol.

25 24. The process according to any one of Claims 20 to
23,
wherein the extraction is carried out under the
condition that the hydrophobic organic solvent is contained
30 in 25 to 65% by volume and the hydrophilic organic solvent
is contained in 5 to 50% by volume.

25. The process according to any one of Claims 18 to
24,
35 wherein the extraction is carried out by continuous

extraction.

26. The process according to any one of Claims 1 to 25,

5 wherein the extraction is carried out under an acidic to a weakly basic condition.

27. The process according to any one of Claims 1 to 26,

10 wherein the cell disruption and/or extraction is carried out under the condition that the reduced coenzyme Q₁₀ is protected from an oxidation reaction.

28. The process according to Claim 27,

15 wherein the condition that the reduced coenzyme Q₁₀ is protected from an oxidation reaction is a deoxygenized atmosphere, a high salt concentration condition, the condition in the presence of a strong acid, the condition in the presence of an antioxidant, or a reduction condition.

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29. The process according to any one of Claims 1 to 28,

25 wherein the reduced coenzyme Q₁₀ is contained at a ratio of not less than 70 mole % among the entire coenzymes Q₁₀

in the case that the reduced coenzyme Q₁₀-producing microorganisms are cultured with shaking (amplitude: 2 cm, 310 reciprocation/min) at 25°C for 72 hours in 10 mL of a culture medium [(glucose: 20 g, peptone: 5 g, yeast extract: 3g, malt extract: 3 g)/L, pH: 6.0] using a test tube (inner diameter: 21 mm, entire length: 200 mm),
the obtained broth is optionally concentrated,
the obtained solution is vigorously shaken for 3 minutes using 10 parts by volume of glass beads (425 to 600
35 μ m) to disrupt the microorganisms under a nitrogen

atmosphere in the concomitant presence of 3 parts by volume of isopropanol and 18.5 parts by volume of n-hexane relative to 10 parts by volume of the broth, and

the prepared hydrophobic organic solvent phase (n-hexane phase) is analyzed by HPLC.

30. The process according to Claim 29, wherein the reduced coenzyme Q₁₀-producing microorganisms have not less than 1 µg/mL of a productivity of reduced coenzyme Q₁₀ per unit culture medium when measured by HPLC under the condition according to Claim 29.

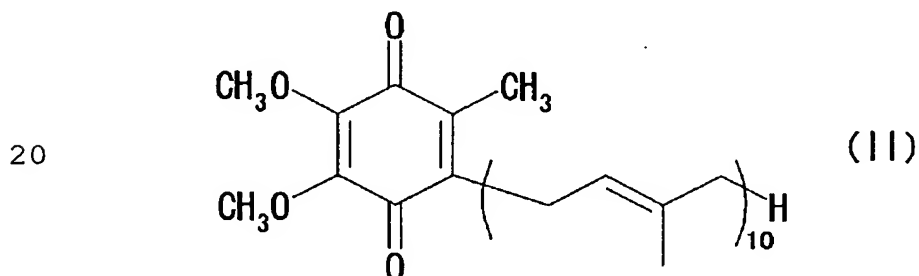
31. The process according to any one of Claims 1 to 30, wherein the microorganisms are microorganisms of the genus Agrobacterium, the genus Aspergillus, the genus Acetobacter, the genus Aminobacter, the genus Agromonas, the genus Acidiphilium, the genus Bulleromyces, the genus Bullera, the genus Brevundimonas, the genus Cryptococcus, the genus Chionosphaera, the genus Candida, the genus Cerinosterus, the genus Exisophiala, the genus Exobasidium, the genus Fellomyces, the genus Filobasidiella, the genus Filobasidium, the genus Geotrichum, the genus Graphiola, the genus Gluconobacter, the genus Kockovaella, the genus Kurtzmanomyces, the genus Lalaria, the genus Leucosporidium, the genus Legionella, the genus Methylobacterium, the genus Mycoplana, the genus Oosporidium, the genus Pseudomonas, the genus Psedozyma, the genus Paracoccus, the genus Petromyc, the genus Rhodotorula, the genus Rhodosporeidium, the genus Rhizomonas, the genus Rhodobium, the genus Rhodoplanes, the genus Rhodopseudomonas, the genus Rhodobacter, the genus Sporobolomyces, the genus Sporidiobolus, the genus Saitoella, the genus Schizosaccharomyces, the genus Sphingomonas, the genus Sporotrichum, the genus Sympodiomyces, the genus

Sterigmatosporidium, the genus Tapharina, the genus Tremella, the genus Trichosporon, the genus Tilletiaria, the genus Tilletia, the genus Tolyposporium, the genus Tilletiopsis, the genus Ustilago, the genus Udeniomyce, the
 5 genus Xanthophyllomyces, the genus Xanthobacter, the genus Paecilomyces, the genus Acremonium, the genus Hyhomonus, or the genus Rhizobium.

32. The process according to any one of Claims 1 to
 10 31,

wherein the obtained reduced coenzyme Q₁₀ is purified optionally and crystallized to obtain a reduced coenzyme Q₁₀ crystal.

15 33. A process for producing the oxidized coenzyme Q₁₀ represented by the following formula (II):



which comprises culturing reduced coenzyme Q₁₀-
 25 producing microorganisms in a culture medium containing a carbon source, a nitrogen source, a phosphorus source and a micronutrient to obtain microbial cells containing reduced coenzyme Q₁₀ at a ratio of not less than 70 mole % among the entire coenzymes Q₁₀,

30 optionally disrupting the microbial cells; and
 either oxidizing thus-produced reduced coenzyme Q₁₀ to oxidized coenzyme Q₁₀ and then extracting the resultant by an organic solvent, or extracting thus-produced reduced coenzyme Q₁₀ by an organic solvent, purifying optionally
 35 and oxidizing the resultant to oxidized coenzyme Q₁₀.

34. The process according to Claim 33,
wherein the production amount of reduced coenzyme Q₁₀
on completion of the culture is not less than 1 µg/mL.

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35. The process according to Claim 33 or 34,
wherein the culture is carried out at 15 to 45°C and
at a pH of 4 to 9.

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36. The process according to any one of Claims 33 to
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wherein the concentration of the carbon source in the
culture is controlled to a concentration that no adverse
effects are substantially caused on the productivity of
reduced coenzyme Q₁₀.

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37. The process according to Claim 36,
wherein the culture is carried out by a fed batch
culture method.

38. The process according to Claim 37,
wherein the carbon source is supplied to the culture
medium separately from other components.

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39. The process according to any one of Claims 33 to
38,

wherein the culture is carried out aerobically.

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40. The process according to any one of Claims 33 to
39,

wherein the microbial cells are disrupted in the
extraction.

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41. The process according to Claim 40,
wherein the cell disruption is carried out by a

physical treatment, a chemical treatment, an enzymic treatment, a heating treatment, an autolysis, an osmolysis or a plasmoptysis.

5 42. The process according to Claim 41,
 wherein the cell disruption is carried out by a
physical treatment.

 43. The process according to Claim 42,
10 wherein the physical treatment is carried out by a
high pressure homogenizer, an ultrasonic homogenizer, a
French press or a ball mill.

 44. The process according to any one of Claims 33 to
15 43,
 wherein the extraction of coenzymes Q_{10} is carried
out from wet cells or dry cells of the microbial cells or
disrupted product thereof by using a hydrophilic organic
solvent.

20 45. The process according to Claim 44,
 wherein the hydrophilic organic solvent is acetone,
acetonitrile, methanol, ethanol, 1-propanol or 2-propanol.

25 46. The process according to any one of Claims 33 to
43,
 wherein the extraction of the coenzymes Q_{10} is
carried out from an aqueous suspension of the microbial
cells or disrupted product thereof by using a hydrophobic
30 organic solvent.

 47. The process according to Claim 46,
 wherein the hydrophobic organic solvent is a
hydrocarbon, a fatty acid ester or an ether.

35

48. The process according to Claim 46 or 47,
wherein the hydrophilic organic solvent is used as an
auxiliary solvent in combination with the hydrophobic
organic solvent.

5

49. The process according to Claim 48,
wherein the hydrophobic organic solvent is a
hydrocarbon, and the hydrophilic organic solvent is an
alcohol.

10

50. The process according to Claim 48,
wherein the hydrophobic organic solvent is an
aliphatic hydrocarbon, and the hydrophilic organic solvent
is a monohydric alcohol containing 1 to 5 carbon atoms.

15

51. The process according to Claim 48,
wherein the hydrophobic organic solvent is at least
one species of hexane and heptane, and the hydrophilic
organic solvent is at least one species of methanol,
ethanol, 1-propanol and 2-propanol.

20

52. The process according to any one of Claims 48 to
51,

wherein the extraction is carried out under the
condition that the hydrophobic organic solvent is contained
in 25 to 65% by volume and the hydrophilic organic solvent
is contained in 5 to 50% by volume.

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53. The process according to any one of Claims 46 to
52,

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wherein the extraction is carried out by continuous
extraction.

54. The process according to any one of Claims 33 to
53,

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wherein the reduced coenzyme Q₁₀ is contained at a ratio of not less than 70 mole % among the entire coenzymes Q₁₀

5 in the case that the reduced coenzyme Q₁₀-producing microorganisms are cultured with shaking (amplitude: 2 cm, 310 reciprocation/min) at 25°C for 72 hours in 10 mL of a culture medium [(glucose: 20 g, peptone: 5 g, yeast extract: 3g, malt extract: 3 g)/L, pH: 6.0] using a test tube (inner diameter: 21 mm, entire length: 200 mm),
10 the obtained broth is optionally concentrated, the obtained solution is vigorously shaken for 3 minutes using 10 parts by volume of glass beads (425 to 600 μm) to disrupt the microorganisms under a nitrogen atmosphere in the concomitant presence of 3 parts by volume
15 of isopropanol and 18.5 parts by volume of n-hexane relative to 10 parts by volume of the broth, and the prepared hydrophobic organic solvent phase (n-hexane phase) is analyzed by HPLC.

20 55. The process according to Claim 54, wherein the reduced coenzyme Q₁₀-producing microorganisms have not less than 1 μg/mL of a productivity of reduced coenzyme Q₁₀ per unit culture medium when measured by HPLC under the condition according to Claim 54.

25 56. The process according to any one of Claims 33 to 55,

wherein the microorganisms are microorganisms of the genus Agrobacterium, the genus Aspergillus, the genus
30 Acetobacter, the genus Aminobacter, the genus Agromonas, the genus Acidiphilium, the genus Bulleromyces, the genus Bullera, the genus Brevundimonas, the genus Cryptococcus, the genus Chionosphaera, the genus Candida, the genus Cerinosterus, the genus Exisophiala, the genus Exobasidium,
35 the genus Fellomyces, the genus Filobasidiella, the genus

Filobasidium, the genus Geotrichum, the genus Graphiola,
 the genus Gluconobacter, the genus Kockovaella, the genus
Kurtzmanomyces, the genus Lalaria, the genus Leucosporidium,
 the genus Legionella, the genus Methylobacterium, the genus
 5 Mycoplasma, the genus Oosporidium, the genus Pseudomonas,
 the genus Pseudozyma, the genus Paracoccus, the genus
Petromyces, the genus Rhodotorula, the genus Rhodospiridium,
 the genus Rhizomonas, the genus Rhodobium, the genus
Rhodoplanes, the genus Rhodopseudomonas, the genus
 10 Rhodobacter, the genus Sporobolomyces, the genus
Sporidiobolus, the genus Saitoella, the genus
Schizosaccharomyces, the genus Sphingomonas, the genus
Sporotrichum, the genus Sympodiomyces, the genus
Sterigmatosporidium, the genus Tapharina, the genus
 15 Tremella, the genus Trichosporon, the genus Tilletiaria,
 the genus Tilletia, the genus Tolyposporium, the genus
Tilletiopsis, the genus Ustilago, the genus Udeniomyces, the
 genus Xanthophyllomyces, the genus Xanthobacter, the genus
Paecilomyces, the genus Acremonium, the genus Hyphomycetes, or
 20 the genus Rhizobium.

57. The process according to any one of Claims 33 to 56,

wherein the obtained oxidized coenzyme Q₁₀ is
 25 purified optionally and crystallized to obtain an oxidized
 coenzyme Q₁₀ crystal.

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